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Catchment Legacies and Trajectories: Hydrologic and Biogeochemical Controls

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Increased nutrient loads delivered from watersheds due to agricultural intensification, industrialization, and urbanization have contributed to the persistence of large hypoxic zones in inland and coastal waters at a global scale. Watershed management practices to target these non-point source pollutants have reportedly resulted in little or no improvement in water quality, even after extensive implementation of conservation measures or Best Management Practices (BMPs). The lag time between implementation of a conservation measure and resultant water quality benefits has recently been recognized as an important factor in the “apparent” failure of these BMPs. Conservation measures are often implemented without explicit consideration of the lag time and with the expectation that they will lead to immediate benefits; the resulting failure to meet such expectations then discourages vital restoration efforts. In order to address this problem, it is important to quantify the lag times associated with watershed management efforts a priori and to implement restoration strategies that are targeted specifically at minimizing lag times as well as maximizing restoration benefits. The focus of this research is to develop an analytical framework for understanding the time lags between land use changes and stream water quality benefits. Watershed lag times are a function of coupled hydrologic and biogeochemical factors that modify pollutant loads as these pollutants are transported through the landscape. Hydrologic factors include the pathways of delivery of the solute to streams (e.g., overland flow, tile flow, or groundwater pathways), and the distribution of travel times along the pathways. Biogeochemical factors include the reactivity of the pollutant, and whether there are internal sources of the pollutant within the landscape. Results of a data synthesis effort of the MARB and the Baltic Basin indicate that landscapes having been subject to fertilizer application for decades have accumulated legacy nutrient stores that will sustain stream nitrate concentrations decades after the cessation of fertilizer application. Here, we have used a travel time-based approach to evaluate the hydrologic legacy and a stochastic carbon nitrogen cycling model to evaluate the biogeochemical legacy. Preliminary results indicate a strong dependence of the spatial allocation of the management practice on the benefits realized, both in terms of reductions in concentrations as well as lag times. A random correlation between implementation of management practices and watershed travel times has been found to result in an interesting linear relationship between the concentration reduction and the percent watershed undergoing land use changes, while power function relationships have emerged for cases of positive and negative correlations.